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Description

TEMPERATURE CONTROL APPARATUS AND METHOD

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a temperature control apparatus and method, and more specifically, to a temperature control apparatus and method for a pulse width modulation (PWM) device.

[0003] 2. Description of the Prior Art

[0004] Presently on a motherboard steady current for a central processing unit (CPU) is provided by a pulse width modulation (PWM) device. For the present CPU, because the process and design technology is becoming more and more advanced, the processing speed of the CPU is becoming faster and faster. Furthermore, the speed level of the CPU has reached the degree of GHz, so the demand current of the CPU has gone from originally being tens of

amperes to now being seventy amperes. The current will even be more than one hundred amperes in the future. That is, the power consumption of the CPU will eventually reach 120 Watts. Thermal issues become a concern due to the high power consumption. The present solution utilizing thermal diffusion involves increasing the thermal-diffusing area or auxiliary thermal-diffusing devices.

[0005] However for the PWM device, when the demand current of the CPU increases, the PWM will generate more heat and consume more power. When the PWM device generates too much heat, the PWM device will be unstable or damaged. Therefore, the PWM device will not provide steady current to the CPU so that the entire motherboard fails. Because the PWM device is often very small and due to the limitation of the motherboard space, the solution of increasing the thermal-diffusing area or auxiliary thermal-diffusing devices is not applicable to the thermal diffusion of the PWM device. So there is a need to find out how to reduce the heat generated by the PWM device effectively.

SUMMARY OF INVENTION

[0006] It is therefore a primary objective of the present invention to provide a temperature control apparatus for a PWM device, to solve the problems mentioned above.

[0007] Briefly summarized, a temperature control apparatus for a pulse width modulation (PWM) device is proposed. The temperature control apparatus includes a temperature detector installed around the PWM device for detecting a present working temperature of the PWM device, and a temperature comparator coupled to the temperature detector and the PWM device for comparing the present working temperature with a maximum limiting temperature and a minimum limiting temperature. When the present working temperature is higher than the maximum limiting temperature, a working frequency of the PWM device will be reduced in a step variation frequency, and when the present working temperature is lower than the minimum limiting temperature, the working frequency of the PWM device will be increased in the step variation frequency.

[0008] Briefly summarized, a method for controlling the temperature of a PWM device includes detecting a present working temperature of the PWM device. When the present working temperature is higher than a maximum limiting temperature, a working frequency of the PWM device will be reduced in a step variation frequency. On the other hand, when the present working temperature is lower than

a minimum limiting temperature, the working frequency of the PWM device will be increased in the step variation frequency.

[0009] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0010] Fig.1is an equivalent circuit diagram of a PWM device and a CPU.

[0011] Fig.2isa circuit diagram of a temperature control apparatus of the PWM device according to a preferred embodiment.

[0012] Fig.3 is a curve chart of a frequency and a temperature of the PWM device.

[0013] Fig.4is a flowchart illustrating actions for controlling the temperature of the PWM device according to the preferred embodiment.

DETAILED DESCRIPTION

[0014] Pulse Width Modulation technology is widely used for controlling the instantaneous electric power. On the mother-

board, the demand steady electric power of the CPU is controlled by the PWM device. Please refer to Fig.1. Fig.1 is an equivalent circuit diagram of a PWM device 10 and a CPU 104. The PWM device includes a pulse width modulator 102, a switch 108, a switch 110, an inductance 112, a capacitance 114, an inductance 116, and a capacitance 120. The input electric power part, the voltage level control part, the electric power feedback part, the working frequency control part, and the output electric power part will be described as follows.

[0015] For the input electric power part, generally the high voltage and the low current will be transferred to the low voltage and the high current. According to the law of the conservation of energy (input voltage×input current=output voltage×output current), for example in Intel Pentium 4 CPU if the input voltage is 12V, the output voltage is 1.5V, and the maximum output current is 70 amperes, the input current will reach 8.75 amperes.

[0016] For the voltage level control part, the core voltage of the CPU 104 is controlled by five pins (VID0-VID4). The pulse width modulator 102 can modulate the voltage level of the CPU 104 according to VID signals transmitted from the CPU 104.

[0017] For the electric power feedback part, the voltage can be fed back from an output end 106 for monitoring the variation of the output voltage on the output end 106 so as to keep the output voltage steady.

[0018] For the working frequency control part, the setting of the working frequency of the pulse width modulator 102 needs to be considered in both the quality of the output voltage and the reduced lifetime of peripheral components due to heat. If the working frequency is too low, the working speed of the electric power system will be slow and the ripple effect of the output voltage will be obvious. However if the working frequency is too high, the computer system will consume more power and the lifetime of peripheral components will be reduced. So the working frequency of the pulse width modulator 102 will be optimized in a proper and stationary working frequency.

[0019] For the output electric power part, when the output electric power is insufficient due to the large current, the switch 110 will be turned off and the switch 108 will be turned on so that the current will be provided from the external power source. When the output voltage is too high, the switch 110 will be turned on and the switch 108 will be turned off so that the PWM device 10 will provide

the stable electric power to the CPU 104 in a loop.

[0020] For general electric components, the loss of power will be transferred into heat. The total power loss (Ploss) of the PWM device 10 = the loss of the conduction (Pconduction) + the loss of the MOSFET switching (Pswitching). Pconduction = $I_o^2 \times R \times D$ (wherein I_o represents output current, R represents MOSFET drain to source on state resistance, and D represents transferring rate= output voltage/input voltage). Pswitching = $V_{in} \times I_o \times f \times [(tr+tf)/2]$ (wherein V_{in} represents input voltage, f represents the working frequency of the PWM device 10, tr represents rising time, and tf represents falling time). When the circuit design of the PWM device 10 is completed, all parameters are fixed except the working frequency. When the demand current of the CPU 104 increases, the Pconduction and the Pswitching also increase. So the working frequency of the PWM device 10 can be reduced so that the Pswitching will be reduced too. For the present PWM device, the range of the working frequency is very wide, like from several KHz to MHz, but actually, for the sake of stability and practicability of the computer system, the working frequency often locates near 200 KHz.

[0021] Please refer to Fig.2. Fig.2 is a circuit diagram of a tem-

perature control apparatus 20 of the PWM device 202 according to a preferred embodiment. The PWM device 202 provides the demand current of a CPU 204. The temperature control apparatus 20 includes a temperature detector 206, and a temperature comparator 208.

[0022] The temperature detector 206 is installed around the PWM device 202 for detecting a present working temperature of the PWM device 202. The temperature comparator 208 is coupled to the temperature detector 206 and the PWM device 202 for comparing the present working temperature with a maximum limiting temperature and a minimum limiting temperature. When the present working temperature is higher than the maximum limiting temperature, the working frequency of the PWM device 202 will be reduced in a step variation frequency. When the present working temperature is lower than the minimum limiting temperature, the working frequency of the PWM device 202 will be increased in the step variation frequency. When the present working temperature is between the maximum limiting temperature and the minimum limiting temperature, the working frequency of the PWM device 202 will not be changed. Besides, the working frequency will not be changed during a predetermined period after

the last change of the working frequency. Because the working frequency of the PWM device 202 changes too often, the computer system will be unstable. Furthermore, the maximum limiting temperature, the minimum limiting temperature, and the step variation frequency are adjustable according to design choice. Fig.3 is a curve chart of the frequency and the temperature of the PWM device 202.

[0023] Please refer to Fig.2 and Fig.4. Fig.4 is a flowchart illustrating actions for controlling the temperature of the PWM device 202 according to the preferred embodiment. First in step S402, the working frequency, the maximum limiting temperature, the minimum limiting temperature, and the step variation frequency will be set up. And then in step s404, the temperature detector 206 can detect the present working temperature of the PWM device 202. The temperature comparator 208 will compare the present working temperature with the maximum limiting temperature and the minimum limiting temperature respectively. In step S406, if the present working temperature is higher than the maximum limiting temperature, the working frequency of the PWM device 202 will be reduced in the step variation frequency. In step S408, if the present working

temperature is lower than the minimum limiting temperature, the working frequency of the PWM device 202 will be increased in the step variation frequency. In step S410, if the present working temperature is between the maximum limiting temperature and the minimum limiting temperature, the working frequency of the PWM device 202 will not be changed. It is important that the working frequency of the PWM device 202 can not change too often, or the computer system will be unstable. For example, the maximum limiting temperature can be 50°C,the minimum limiting temperature can be 10°C, the step variation frequency can be 10 KHz, and the working frequency of the PWM device 202 can be 200KHZ. When the temperature detector 206 detects that the present working temperature of the PWM device 202 is higher than 50°C, the temperature comparator 208 will reduce the working frequency of the PWM device 202 from 200 KHz to 190 KHz. When the temperature detector 206 detects that the present working temperature of the PWM device 202 is lower than 10°C, the temperature comparator 208 will increase the working frequency of the PWM device 202 from 200 KHz to 210 KHz. When the temperature detector 206 detects that the present working temperature of the PWM

device 202 is between 10℃ and 50℃ the working frequency of the PWM device 202 will stay at 200 KHZ.

[0024] From the above-mentioned description, when the present working temperature is higher than the maximum limiting temperature, the working frequency of the PWM device 202 will be reduced. Therefore, the Pswitching will also be reduced so that the PWM device 202 will generate less heat and the lifetime of the PWM device 202 will be increased.

[0025] In contrast to the prior art, the present invention can provide the temperature detector for detecting the present working temperature of the PWM device and a temperature comparator for comparing the present working temperature with the maximum limiting temperature and the minimum limiting temperature. When the present working temperature is higher than the maximum limiting temperature, the working frequency of the PWM device 202 will be reduced. Therefore, the power consumption will also be reduced so that the PWM device 202 will generate less heat and the lifetime of the PWM device 202 will be increased. When the present working temperature is lower than the minimum limiting temperature, the working frequency of the PWM device 202 will be increased. There-

fore, the ripple effect will be reduced. Furthermore, the present invention does not have to utilize any thermal-diffusing device, so the cost will be reduced.

[0026] Those skilled in the art will readily observe that numerous modifications and alterations of the device and the method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.